

# Vibration Control & Analysis



**Time/Data**  
A GR COMPANY





The 1923V Digital Vibration Control System synthesizes and controls the excitation for vibration testing. The all digital system generates a random (Gaussian) sequence of numbers that are converted to an analog signal. The analog signal provides the excitation to a power amplifier that in turn drives either an electromagnetic or electrohydraulic shaker system. Additionally, the 1923V controls the vibrations experienced by the test specimen by comparing the spectrum of the observed vibrations with a stored reference. The Gaussian signal is controlled and synthesized in the frequency domain. The driving signal is obtained through a discrete Fourier transform performed by a high-speed special purpose fast Fourier transform processor. This also performs the spectral analysis of observed vibrations.

The 1923V represents the first major innovation in vibration testing in over a decade. Until its introduction, the function was performed by analog equipment consisting of a noise generator, 80 parallel variable gain band pass filters for spectral shaping of the spectrum, and 80 identical filters for estimating the spectrum of the observed vibrations.

**Time/Data**  
A GR COMPANY



## The 1923V system provides the following advantages:

### GREATER RESOLUTION

The resolution of the control and synthesis can be extended by at least an order of magnitude without any noticeable cost increment. The 1923V can readily provide a resolution of 1/1000 rather than 1/80 which represents the economic limit of the analog implementation. This means that systems with sharper resonances can be controlled.

### DIGITAL CONTROL

Digital systems can readily provide operator convenience features that would not be feasible in analog implementations:

- Conversational control mode.  
Alpha-Numeric displays.  
Interactive graphics for display and specification of test conditions.

Digital systems can effectively monitor test conditions and when necessary, initiate shut-down procedures that will minimize the possibility of damage to the test specimen.

### ZERO-VARIANCE-NOISE

Because the system numerically synthesizes the (pseudo) random Gaussian sequences used for excitation, advantage is taken of this "a priori" knowledge in the estimation of the response spectrum of the shaker system. This permits the spectrum to be determined without the usual variance associated with the estimation of the spectrum of a Gaussian process. This feature (zero-variance-noise) permits, for the first time:

- Rapid stabilization of test conditions that permit valid short-term tests.
- Simulation of time-varying environments such as might be experienced by a missile during its launch phase.

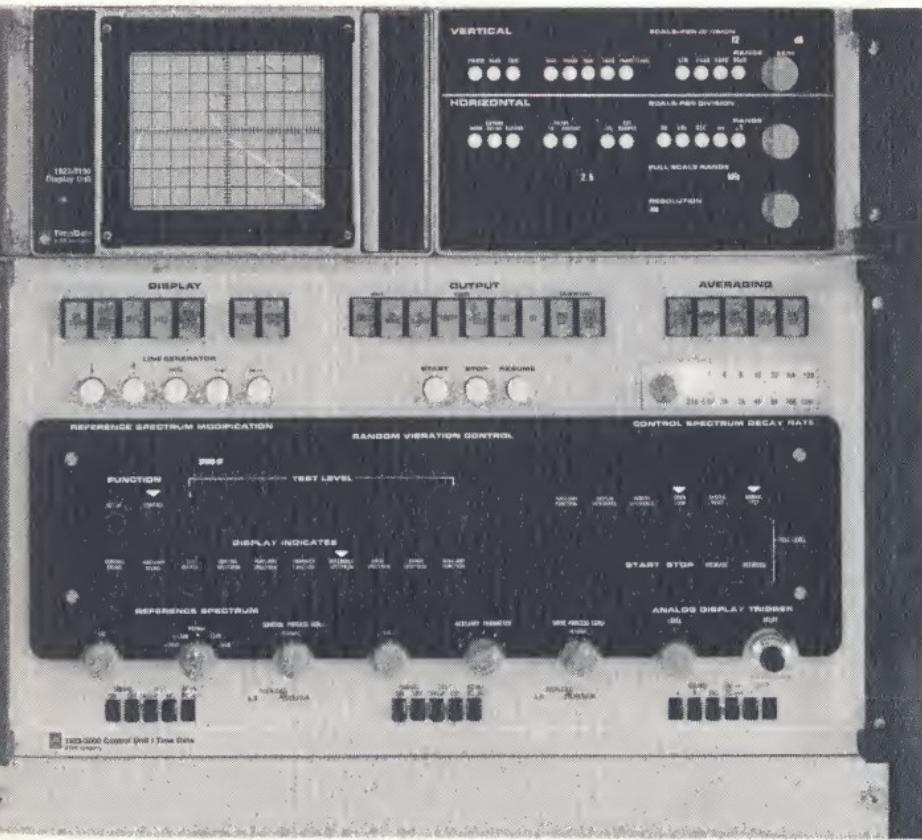
### COMPLETE ANALYSIS

The same apparatus may be used to analyze the results for the vibration tests. The alternative software package permits the system to operate as a 1923 Time-Series-Analyzer which includes the following capabilities:

Complete analysis—The system design allows you to construct any desired compound processing and input/output operations for automatic or repetitive data-reduction routines. Parallel processing in both the processor and controller permits wide-band performance. Complex, repetitive sequences can be initiated automatically or at the push of a button, which eliminates the need for a trained operator to set up and supervise each measurement.

Pre-programmed pushbutton functions:

Direct/Inverse FFT  
Auto-/Cross-Spectrum  
Transfer/Coherence Function  
Auto-/Cross-Correlation  
Waveform Averaging



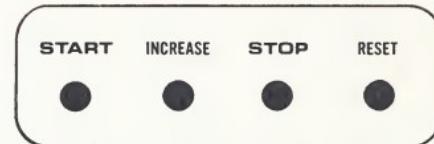
#### Action Initiation Controls:

START—initiates start of either set-up of parameters or test.

STOP—stops operation; initiates shut-down routine when in test mode.

INCREASE—causes test excitation to be increased to full level.

RESET—resets system into stand-by state after the completion or abortion of a test.



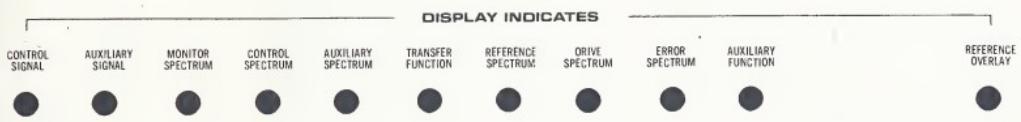
#### Function Selection:

SET UP—puts system in set-up mode to allow operator to enter the test parameters. The START button must be depressed to initiate the conversational routine via the TTY. The STOP button may be depressed at any time to abort the SET UP state and return to STANDBY.

TEST—puts system in test mode. Press START to begin operation.

#### FUNCTION





### Display Selection Controls:

**CONTROL SIGNAL**— displays the analog control signal (Channel A).

**AUXILIARY SIGNAL**— displays the analog auxiliary (Channel B).

**MONITOR SPECTRUM**—displays auto spectrum of control signal.

**CONTROL SPECTRUM**—displays auto spectrum of control signal as it is used for control.

**AUXILIARY SPECTRUM**—displays auto spectrum of auxiliary (Channel B) signal. (Optional).

**TRANSFER FUNCTION**—displays transfer function. (Optional)

**REFERENCE SPECTRUM**—displays reference auto spectrum.

**DRIVE SPECTRUM**—displays auto spectrum of drive signal.

**ERROR SPECTRUM**—displays the ratio of the control and reference spectrums.

**AUXILIARY FUNCTION**—displays the auxiliary function. (Optional).

**REFERENCE OVERLAY**—allows the reference spectrum to be superimposed on any other display.

### Status Indicators

Five indicator lamps—STANDBY, SET UP, RUN, COMPLETE and ABORT—are used to indicate the major state that the system is in. ABORT is indicated if, for any reason, a test stops prematurely.

NOT EQUALIZED is indicated whenever the control spectrum is not within tolerance.

INVALID PARAMETER is indicated whenever an illegal parameter is selected from the control panel.

STATUS



SPECTRUM MODIFICATION



SPECTRUM DECAY

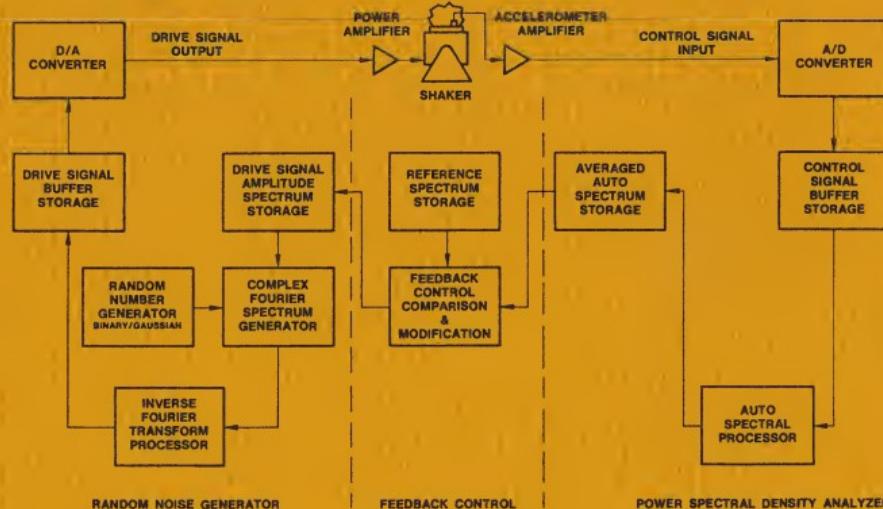
## Example

A typical set-up procedure for a random test is shown in Fig. 1. By selecting SET-UP as the function the machine is to perform, and pressing START, the operator is put into communication with the machine via the tele-typewriter. The machine asks questions which the operator responds to by typing numbers. After answering all the questions, and making any necessary corrections, the operator may elect to have the test parameters punched on paper tape so that the next time that the same test is to be performed it may be set-up by just loading the tape. When ready to perform the test, the operator selects CONTROL and presses START.

```
ENTER PARAMETERS 1=YES 0=NO: 0
CORRECTIONS 1=YES 0=NO: 0
LIST 1=YFS 0=NO: 1
  1 PANDWIDTH, HZ.: 5120
  2 FREQUENCY RESOLUTION 64/128/256/512: 256
FREQUENCY INCREMENT, HZ.: 20
REFERENCE SPECTRUM:
  3 INITIAL SLOPE DR/OC1: 24
  4 FREQUENCY HZ.: 500
  LEVEL GSQR/HZ.: 0.1
  5 FREQUENCY HZ.: 2500
  LEVEL GSQR/HZ.: 0.1
  6 FINAL SLOPE DR/OC1: 48
  7 ZERO VARIANCE MODE 1=YFS 0=NO: 1
```

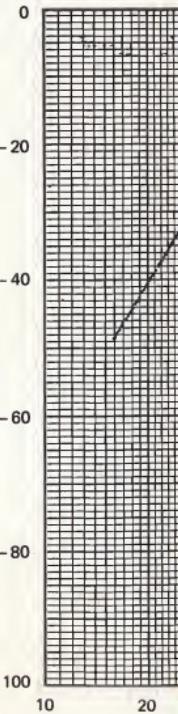
Fig. 1

Functional block diagram of random vibration control system.



XY Plot Speci

POWER SPECTRAL DENSITY, dB



FIRST CLASS  
PERMIT No. 350  
Palo Alto  
California

## BUSINESS REPLY MAIL

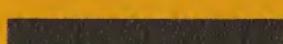
No postage necessary if mailed in the United States

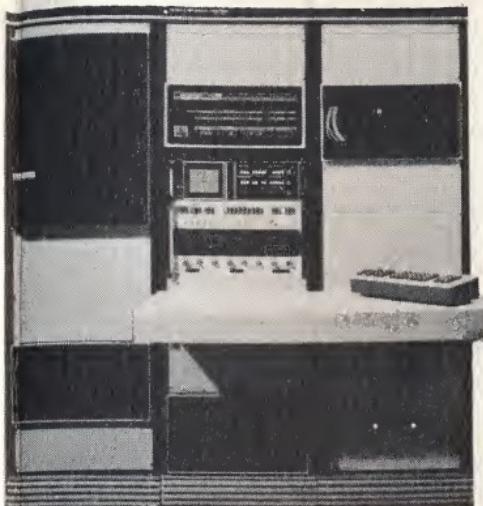
POSTAGE WILL BE PAID BY:



**Time/Data**  
A GR COMPANY

490 SAN ANTONIO RD.,  
PALO ALTO, CALIFORNIA 94306





**Time/Data**  
A GR COMPANY

Please Send Information On:

- Random Control
- Sine Control
- Transient Control
- Signal Analysis
- Have an Applications Engineer Call on Me
- I would Like to be on Mailing List

My Application is \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Name: \_\_\_\_\_

Title: \_\_\_\_\_ Dept: \_\_\_\_\_

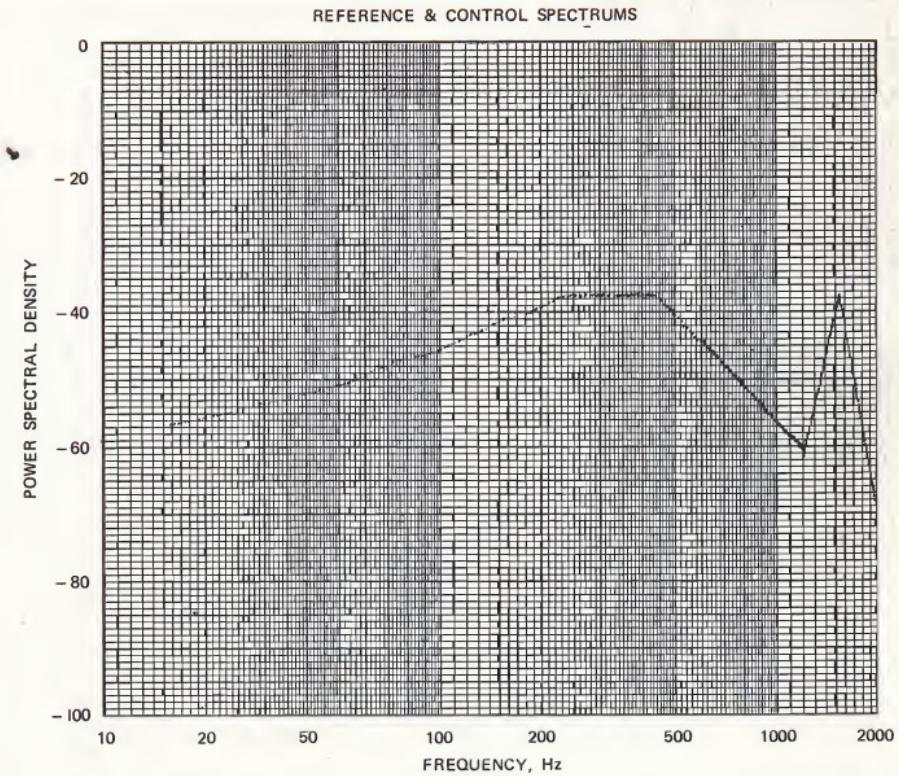
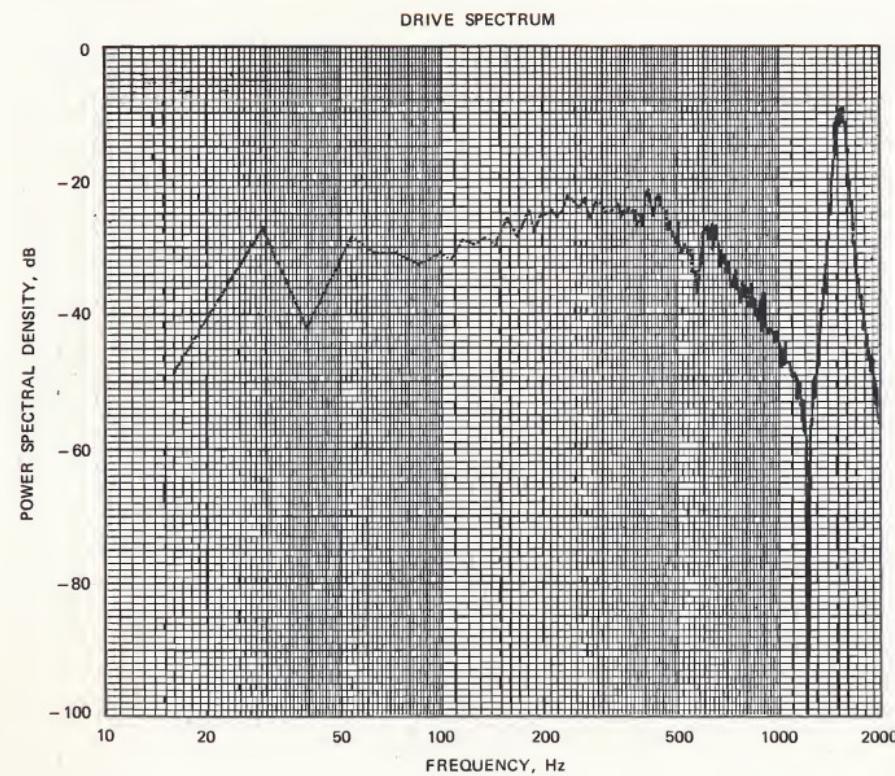
Company: \_\_\_\_\_

Address: \_\_\_\_\_

City: \_\_\_\_\_ State: \_\_\_\_\_ Zip: \_\_\_\_\_

Phone: \_\_\_\_\_ Area Code: \_\_\_\_\_

## XY Plot Specimen





### Display Selection Controls:

**CONTROL SIGNAL**—displays the analog control signal (Channel A).

**AUXILIARY SIGNAL**—displays the analog auxiliary (Channel B).

**MONITOR SPECTRUM**—displays auto spectrum of control signal.

**CONTROL SPECTRUM**—displays auto spectrum of control signal as it is used for control.

**AUXILIARY SPECTRUM**—displays auto spectrum of auxiliary (Channel B) signal. (Optional).

**TRANSFER FUNCTION**—displays transfer function. (Optional)

**REFERENCE SPECTRUM**—displays reference auto spectrum.

**DRIVE SPECTRUM**—displays auto spectrum of drive signal.

**ERROR SPECTRUM**—displays the ratio of the control and reference spectrums.

**AUXILIARY FUNCTION**—displays the auxiliary function. (Optional).

**REFERENCE OVERLAY**—allows the reference spectrum to be superimposed on any other display.

### Status Indicators

Five indicator lamps—**STANDBY**, **SET UP**, **RUN**, **COMPLETE** and **ABORT**—are used to indicate the major state that the system is in. **ABORT** is indicated if, for any reason, a test stops prematurely,

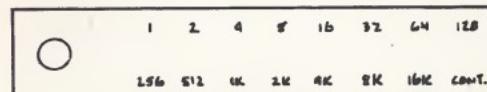
**NOT EQUALIZED** is indicated whenever the control spectrum is not within tolerance.

**INVALID PARAMETER** is indicated whenever an illegal parameter is selected from the control panel.

STATUS



SPECTRUM MODIFICATION



SPECTRUM DECAY



**Time/Data**  
A GR COMPANY

490 SAN ANTONIO RD., PALO ALTO, CALIFORNIA 94306 • 415 327-8322

BOSTON 617 646-0650 / CHICAGO 312 992-0600  
LOS ANGELES 714 540-9830 / NEW YORK (N.Y.) 212 964-2722 (N.J.) 201 791-8990  
WASHINGTON, D.C. 301 881-5333  
TORONTO 416 252-3395 / ZURICH (051) 47 70 20